

## Time structure of a Super (Beta) Beam

**Does the neutrino detector put any constrain on the time structure of the neutrino beam?**

- Underground detectors: limit the atmospheric neutrino background
- Surface detectors: limit the charge cosmic rays noise

# Atmospheric neutrino background

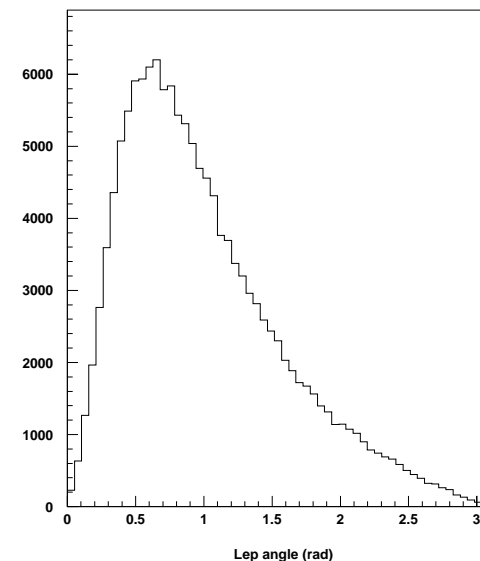
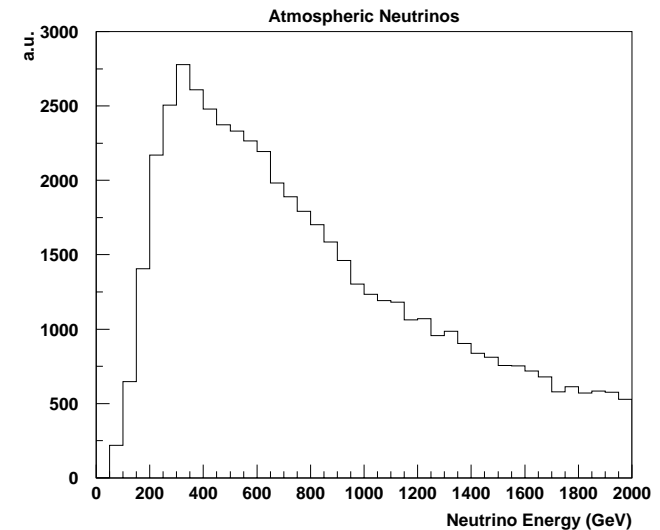
## Why are they dangerous?

Atmospheric neutrinos come in two flavors:  $\nu_e$  and  $\nu_\mu$ , so they can fake any signal.

Their energy spectrum fully covers Super and Beta Beam spectra.

They don't necessarily come from the decay ring, but outgoing lepton direction is loosely correlated with the neutrino energy direction in QE events.

The only viable tool to keep them at a negligible rate is to keep very short the live time of the neutrino beam.



## Oscillation signals

From J.E.Campagne, M. Maltoni, M.M., T.Schwetz, hep-ph/0603172.

	$\beta B$		SPL		T2HK	
	$\delta_{CP} = 0$	$\delta_{CP} = \pi/2$	$\delta_{CP} = 0$	$\delta_{CP} = \pi/2$	$\delta_{CP} = 0$	$\delta_{CP} = \pi/2$
appearance $\nu$						
background		113		600		1017
$\sin^2 2\theta_{13} = 0$		24		41		84
$\sin^2 2\theta_{13} = 10^{-3}$	66	76	93	10	181	18
$\sin^2 2\theta_{13} = 10^{-2}$	285	314	387	126	754	240
appearance $\bar{\nu}$						
background		127		500		1428
$\sin^2 2\theta_{13} = 0$		23		36		90
$\sin^2 2\theta_{13} = 10^{-3}$	64	10	74	104	188	261
$\sin^2 2\theta_{13} = 10^{-2}$	271	100	297	390	746	977

## Atmospheric neutrino background in the $\gamma = 100$ beta beam

- Generate with Nuance atmospheric neutrinos in the Memphys fiducial
- Apply the tight particle identification cuts.
- Reconstruct them with the QE algorithm assuming they are coming from CERN.
- Accept them in the energy and direction window of the BB events:
- Apply the baseline BB duty cycle:  $2.2 \cdot 10^{-3}$

The rate would be about  $2.3 \times 10^3$  backgrounds year (full solar year)

**A duty cycle of order  $5 \cdot 10^{-3}$  is needed to keep this background negligible**

SPL and T2HK have somewhat looser constrain given the higher rate of backgrounds in the experiment

## A tighter constrain comes if you want to run the detector on surface

Charged cosmic rays can fuzzy the trigger

Dead time could become too high.

Neutral cosmic rays could mimic  $\nu_e$  interactions

The duty cycle would depend very much from the detector technology.

So far only NO $\nu$ A proposed to run on surface, with a duty cycle of  $\sim 3 \cdot 10^{-5}$ .

## Conclusions

- Atmospheric neutrino background put a limit on duty cycle below  $5 \times 10^{-3}$
- If you want to run the detector on surface, this constrain becomes two order of magnitude tighter.